Case Study No. 23   Waterborne Coatings
Shafer Commercial Seating
Denver, CO

Background

Shafer Commercial Seating manufactures chairs, tables, and booths for hotels and restaurants. They supply both solid wood and upholstered wood chairs. Their products are mostly solid wood, but some laminate is used, particularly for the booths and some table tops. The facility has 18 employees in their finishing department during the day shift, 5 during the night shift, and operates 5 days per week. Shafer is subject to the Wood Furniture NESHAP, although their current actual HAP emissions are below the major source threshold. Approximately 375 chairs per day and 150 table tops per week are coated at the facility, although Shafer does some time-consuming custom work that occasionally reduces these averages. Shafer converted to waterborne coatings in 1996 to reduce their VOC and HAP emissions.

Manufacturing and Coating Operations

Shafer imports their chair frames, which are made primarily of European beech. The chair frames are coated, and then upholstery may be added. The wood components for the tables and booths are milled on-site. Oak, maple, mahogany, and cherry are the primary wood species used, but Shafer also fills custom orders for other species. Laminates typically are used as booth components.


Coating line

Shafer has one coating line. During the day shift, chairs are coated. Table tops and a smaller number of chairs are coated during the night shift. The chairs move along the coating line on pallets that hang from an overhead conveyor system. The table tops are fastened to vertical bars that hang from the overhead conveyor. The line travels at about 6 feet per minute.

Chairs are finished only with waterborne coatings. The chair frames first are sanded by hand. The stain is sprayed onto the chair (as little as possible, to prevent excessive grain raise) and wiped by hand. The stain is sprayed using Kremlin air-mix guns, similar to air-assisted airless guns, and each stain color has a dedicated line from the mix room. Custom colors are sprayed from small pressure pots at the line. A toner (a diluted stain) is applied using an HVLP gun to even out the stain color and the piece is wiped a second time. The chair then passes through an IR oven to dry the stain. Fans also have been installed above the conveyors to aid in the drying process.

The sealer then is applied using airless spray guns. The facility found that this type of gun allows them to apply more sealer than an air-assisted airless gun. The chair then passes through a second IR oven and makes two passes through cooling air. Next, the chairs are taken off the line, one at a time, and placed in a machine that uses ceramic beads to polish, or "pound in," the sealer. Before Shafer started using this machine, the operators would sometimes sand through the sealer in an attempt to control the grain raise caused by the waterborne coatings. The chairs are lightly sanded by hand and any dust is wiped off before the topcoat is applied.


Sealer application


IR oven

The chairs receive the first topcoat and pass through another IR oven for drying. The topcoat is applied using the air-mix spray guns. The chairs then are lightly sanded and receive a final topcoat. The last step is the final IR oven. Chairs with finish defects are sanded and refinished if the defect cannot be repaired by applying another topcoat.

Table tops do not go through as many coating steps as the chair frames. They first receive a waterborne stain, which is hand wiped. This stain is toned, as necessary, to even out the color. An IR oven dries the stain. The table tops do not receive a sealer, but do receive a solvent-borne, high-solids topcoat. This coating is about 35 percent solids, contains some acetone, and has less than 1 pound VOC per pound solids. The first topcoat is dried in an IR oven and then sanded. A final topcoat is applied and then dried in an IR oven. After the table tops are coated, the bases are attached.

Coatings are received in 5-gallon buckets (stains) or 55-gallon fiberboard drums. The used fiberboard drums are crushed once any leftover coating is dried. The used coating containers are not hazardous waste, and are disposed of as landfill waste.

Gluing Operations

Shafer uses waterborne and hot melt glues. Hot melt glues are used for applying edge banding and for applying foam to wood. Waterborne products are used for applying wood to wood and vinyl to wood. The operators had to be retrained when the facility switched from solvent-borne glues to waterborne glues. With the waterborne glues, the glue is applied to both pieces, allowed to dry, and then the pieces are put together to form the bond. With the solvent-borne glue, the operators sprayed the glue and immediately bonded the pieces together. Shafer tried a two-component glue, but it did not perform well and tended to clog their equipment. Glues are received in steel drums or plastic containers. Empty steel drums are sent to a local facility for recycling, and the empty plastic containers are disposed of as landfill waste.

Cleaning Operations

Shafer uses hot water to clean the equipment that is used to apply the waterborne coatings. They tried using a waterborne cleaning solution they bought from their coating supplier, but it proved to be too hard on their equipment. They do not clean the equipment often, since dedicated lines are used for each color of stain, and for the sealer and topcoat. The same sealer and topcoat are applied to most products. The gun tips are cleaned regularly, however, and the equipment is cleaned after applying a custom color. Shafer formerly used solvent to clean all equipment.

Conversion to Waterborne Coatings

Shafer began researching waterborne coatings in the early 1990s. They wanted to reduce emissions, and their management made a commitment to switch to waterborne coatings. They performed extensive testing in 1995, and began using the waterborne coatings in production in February 1996. These coatings replaced traditional solvent-borne coatings. They depended heavily on their coating supplier for advice on equipment selection, particularly the IR ovens. The coating system has undergone several changes from the original system because of problems with foaming, dry time, performance, and color. Facility personnel stated that it took 3 months to produce a product with an acceptable finish with the new system. They would like to further improve upon the appearance they currently achieve.

Shafer’s largest obstacle in making the waterborne system work has been the waterborne stains. They have had problems with dry time, excessive grain raise, and color consistency. At first, the water in the new stain would evaporate before they could wipe the stain. The coating supplier reformulated the stain to prevent this problem. Shafer would like to be able to take the chairs off the coating line after the stain application to allow for more drying time, but their current space does not allow that. If the stain is not dry before additional coatings are applied, the topcoat does not perform as well. Therefore, they have increased the IR oven air circulation and temperature, and added fans above the line to further aid in drying.

The waterborne stain also causes grain raise, which produces a rougher finish. Shafer had to add the piece of polishing equipment because operators were sanding through the seal coat in an attempt to control the grain raise caused by the waterborne stains. When the seal coat was sanded through, the topcoat then caused a second grain raise. Shafer personnel feel that their product is not as smooth to the touch as a product finished with a traditional solvent-borne coating.

Color consistency also is an issue with the waterborne stains. During the test period, the color of any particular stain they received from the coating supplier was not consistent from shipment to shipment, and some of the stains would separate in their containers during shipment. Shafer still has to adjust some of their stains with dye to achieve a consistent color between shipments, especially for dark colors. They also had to add a toning step to the coating process to even out the color of the stain on the wood. In their original solvent-borne system, they stained, sealed, and applied two topcoats. For every 20 gallons of stain purchased, about 1 gallon is used in the toning step. The waterborne stains Shafer uses do not produce a product with the same appearance as the solvent-borne stains they had been using. Facility personnel characterize the finish achieved by the waterborne stains as “muddy,” because the natural grain of the wood does not show through as well.

With the waterborne sealers, the main issue is the operator’s ability to sand the coating. The waterborne sealer is harder than the solvent-borne sealer the facility used previously, and requires extra effort to sand. As mentioned previously, the seal coat sometimes was sanded through in an attempt to smooth out the roughness caused by grain raise.

The waterborne topcoat has a higher solids content than the solvent-borne topcoat used previously (41 percent solids versus 25 percent solids). However, the facility still applies two coats of topcoat because they can’t apply a sufficient amount of the waterborne coating in one step. Shafer tried a catalyzed waterborne topcoat, but even though it produced a better looking product, it was more costly and was hard on their equipment because it was so viscous. They had to turn up the pressure on their spray guns and the coating tended to clog the guns or catalyze inside the guns. They rebuilt their spray guns every 2 to 3 days while they were testing this coating. Therefore, they discontinued use of the catalyzed topcoat.

For the table tops, Shafer currently is investigating a waterborne urethane topcoat to replace their solvent-borne topcoat. The urethane coating would allow them to apply one coat of topcoat instead of two. Orange peel and hardness are issues with this coating that they are trying to resolve with the coating supplier.

Shafer continues to experiment with waterborne coating systems from several other suppliers, including European suppliers, in an attempt to find a system that produces a better appearance than they currently are achieving. Shafer was the first furniture company in their area to switch to a waterborne system, and their coating supplier did not have much experience with waterborne systems at that time. Facility personnel expected a faster conversion and a more consistent product. They also feel that because acetone is no longer considered a VOC, many coating suppliers simply have reformulated their solvent-borne coatings to contain acetone in order to reduce the VOC/HAP content, and have not made enough of an effort to improve their waterborne systems.

Costs
During the conversion to the waterborne system, the facility spent about $300,000 rearranging their finishing area, adding new equipment, and changing the configuration of their line to accommodate the new coating system. They had to purchase and install stainless steel lines, mixing pots, and guns, which cost approximately $50,000. The waterborne coatings also are more expensive than the solvent-borne coatings they were using. The stains have increased in cost to as much as $50 per gallon. The topcoats have increased in cost from approximately $10.50 per gallon to approximately $16 per gallon. Although the solids content of the clearcoats is higher, Shafer still applies two coats of topcoat, so they do not believe they are using much less of the waterborne coating. Due to problems with grain raise and the hardness of the sanding sealer, they have increased the amount of sandpaper they purchase. Shafer also estimates they have lost about $1 million in sales because of problems with products that had been coated with the new waterborne coatings. The company did, however, experience a savings in fire insurance with the switch to waterborne coatings, and their use of hot water instead of solvent for cleaning equipment also results in a small cost savings.

Emissions
Shafer has reduced their emissions of both VOCs and HAPs over the past few years. Their current VOC emissions are far less than their permit limit of 90 tons per year. In 1995, their VOC emissions were over 80 tons per year. In 1996, this number decreased to 32 tons, and in 1997, to 15 tons. Shafer's HAP emissions were 17 tons in 1996 and 4 tons in 1997. Their 1998 emissions through September were approximately 11.5 tons of VOCs and 2.6 tons of HAPs. Their HAP emissions are primarily glycol ethers.